

(12) UK Patent Application (19) GB (11) 2 115 980 A

(21) Application No 8300968

(22) Date of filing 14 Jan 1983

(30) Priority data

(31) 57/009197

57/009198

57/009199

57/009200

57/009201

(32) 22 Jan 1982

22 Jan 1982

22 Jan 1982

22 Jan 1982

(33) Japan (JP)

(43) Application published

14 Sep 1983

(51) INT CL³

H01L 27/14

(52) Domestic classification

H1K 1EA 4C11 4C1U 9C2

9C3 ECA

(56) Documents cited

None

(58) Field of search

H1K

(71) Applicants

Sanyo Electric Co. Ltd.,

(Japan),

18 Keihanhondori

2-chome,

Moriguchi-shi,

Osaka-fu,

Japan.

(72) Inventors

Yukinori Kuwano,

Shoichi Nakano,

Masaru Takeuchi.

(74) Agent and/or Address for Service

R.G.C. Jenkins and Co.,

12-15 Fetter Lane,

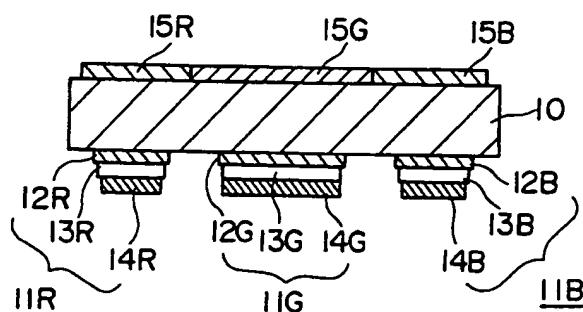
London EC4A 1PL.

(54) Color sensor

(57) The light active layers (13R, 13G, 13B) of a colour sensor are formed of an amorphous semiconductor or a mixed

phase semiconductor of an amorphous semiconductor and a microcrystallized semiconductor. The color sensor further comprises a light transmissible substrate (10). A red color filter (15R), a green color filter (15G) and a blue color filter (15B) are provided on one major surface of the light transmissible substrate (10). A red color light sensitive element (11R), a green color light sensitive element (11G) and a blue color light sensitive element (11B) are provided on other major surface of the light transmissible substrate (10) opposed to the red color filter (15R), the green color filter (15G) and the blue color filter (15B), respectively. Respective light sensitive elements (11R, 11G, 11B) are formed such that respective transparent electrodes (12R, 12G, 12B), respective light active layers (13R, 13G, 13B) and respective metal electrodes (14R, 14G, 14B) are stacked, in this order, on the light transmissible substrate (10).

FIG. 3B



GB 2 115 980 A

FIG. 1

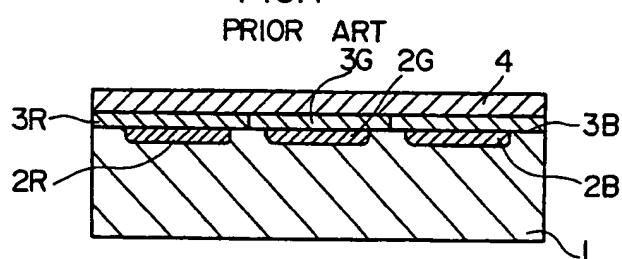


FIG. 2

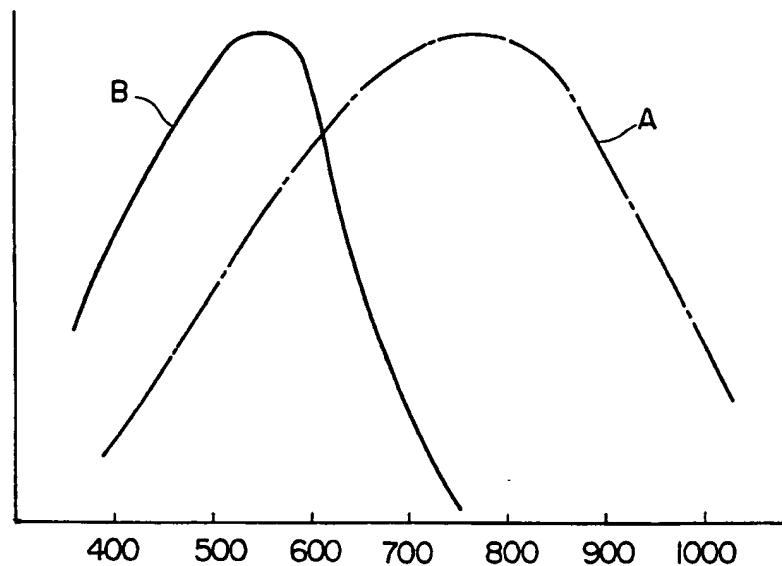
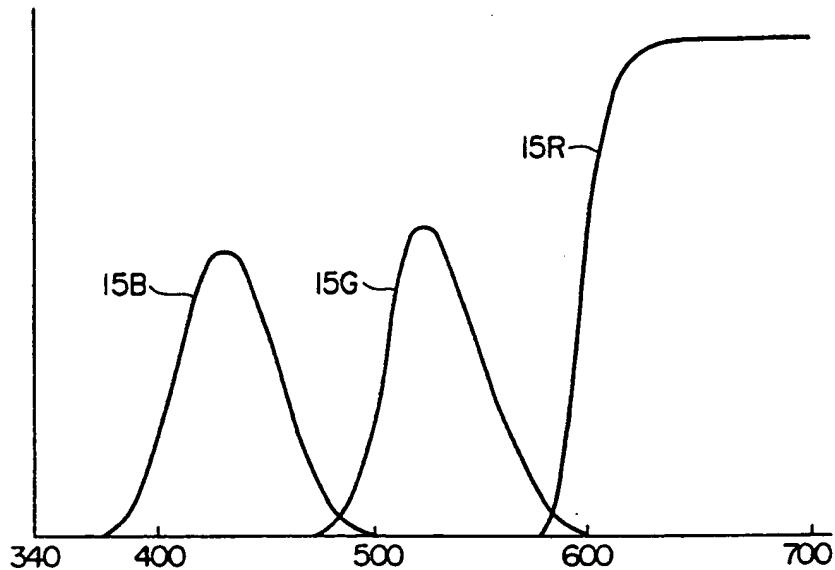


FIG. 4



2115980

2/7

FIG. 3A

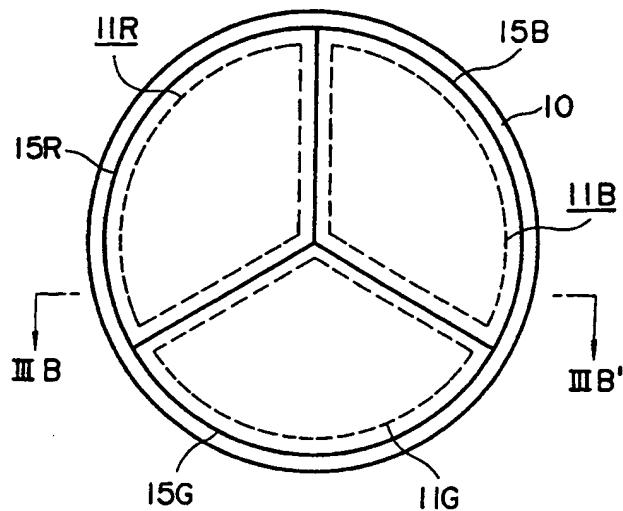


FIG. 3B

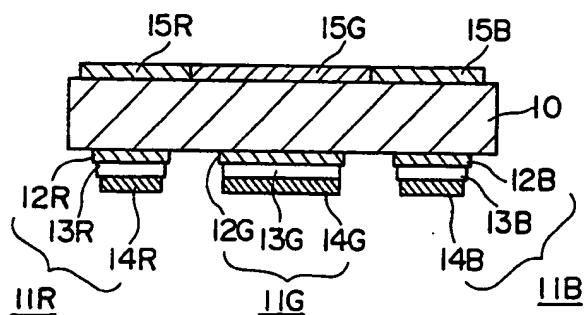


FIG. 5

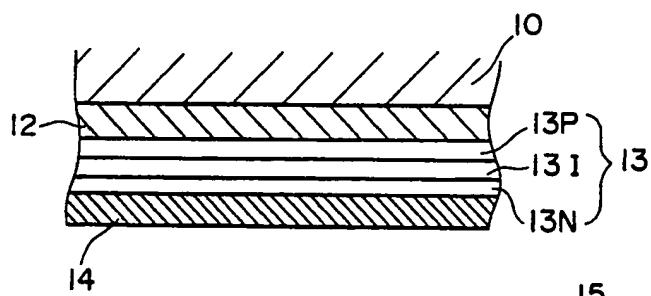


FIG. 6

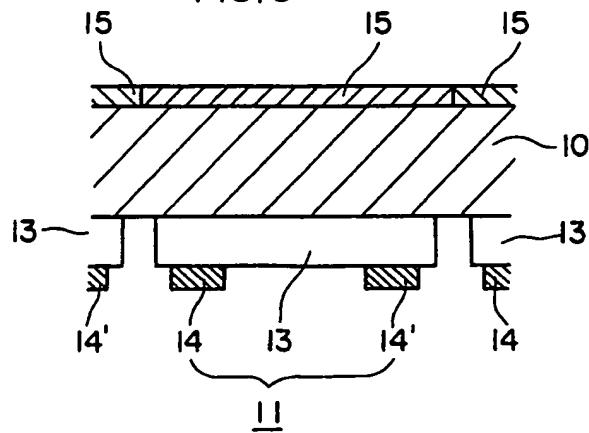


FIG. 7A

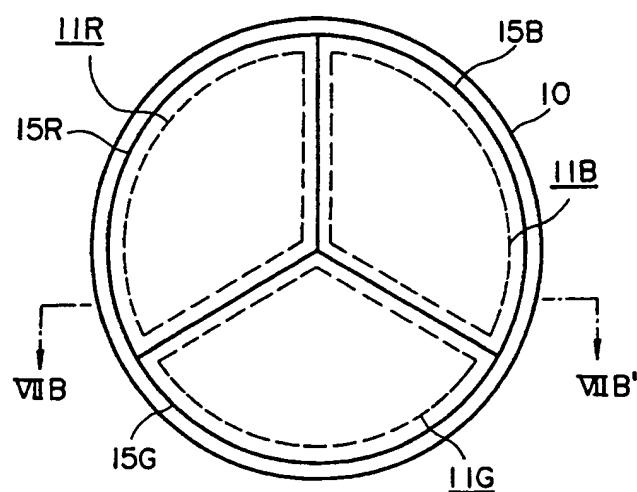


FIG. 7B

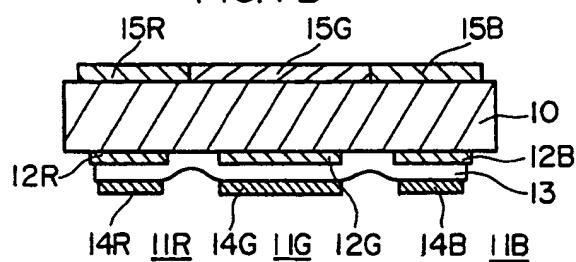


FIG. 13

FIG. 10

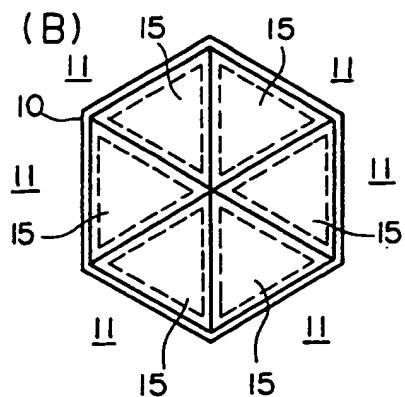
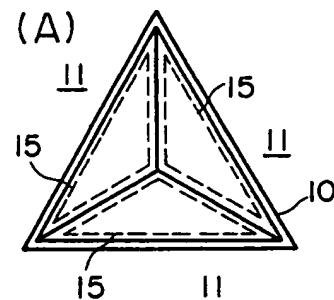
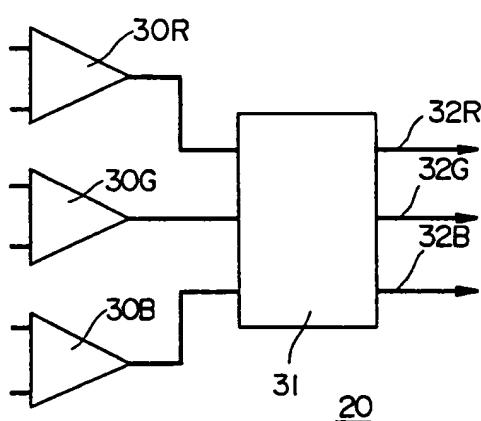


FIG. 8A

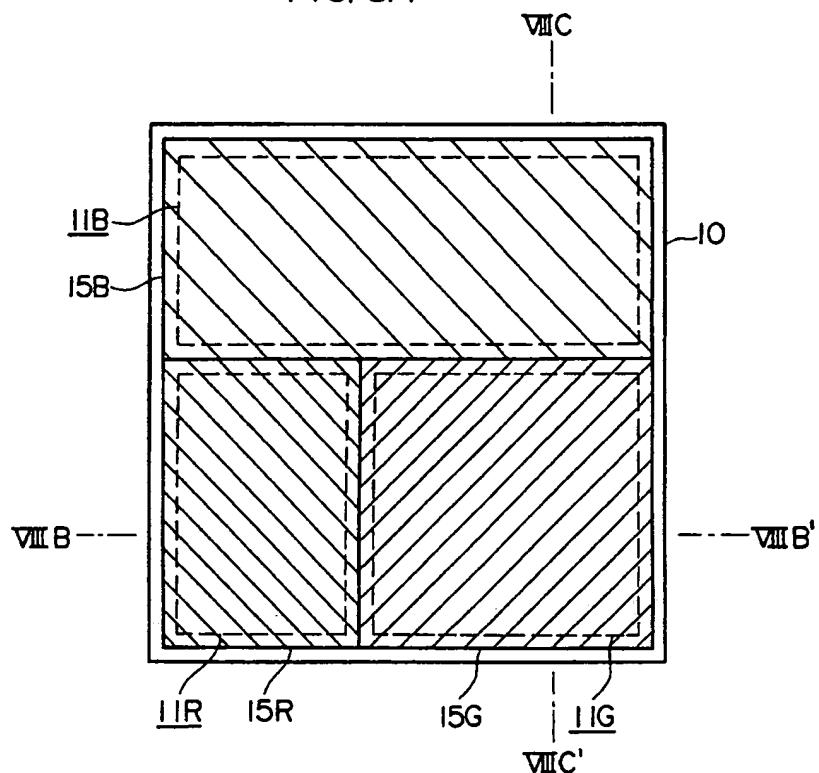


FIG. 8B

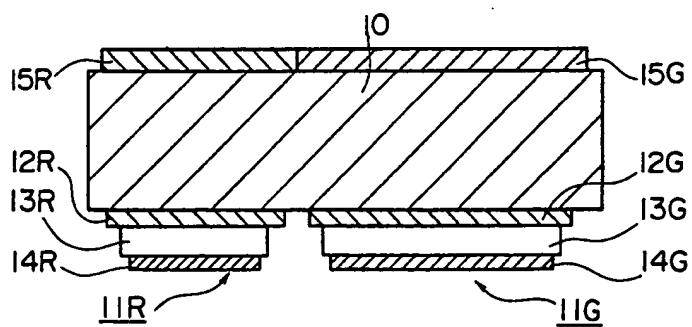
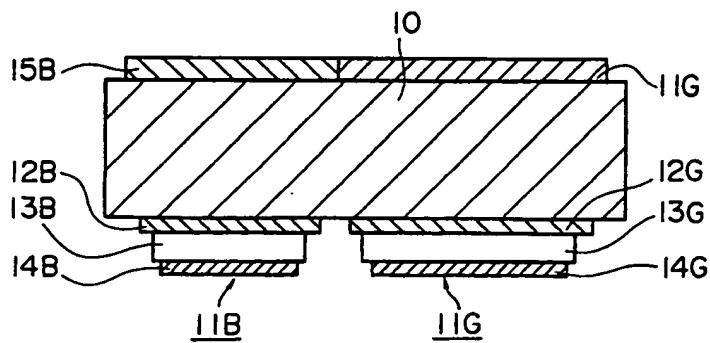


FIG. 8C



2115980

FIG. 9A

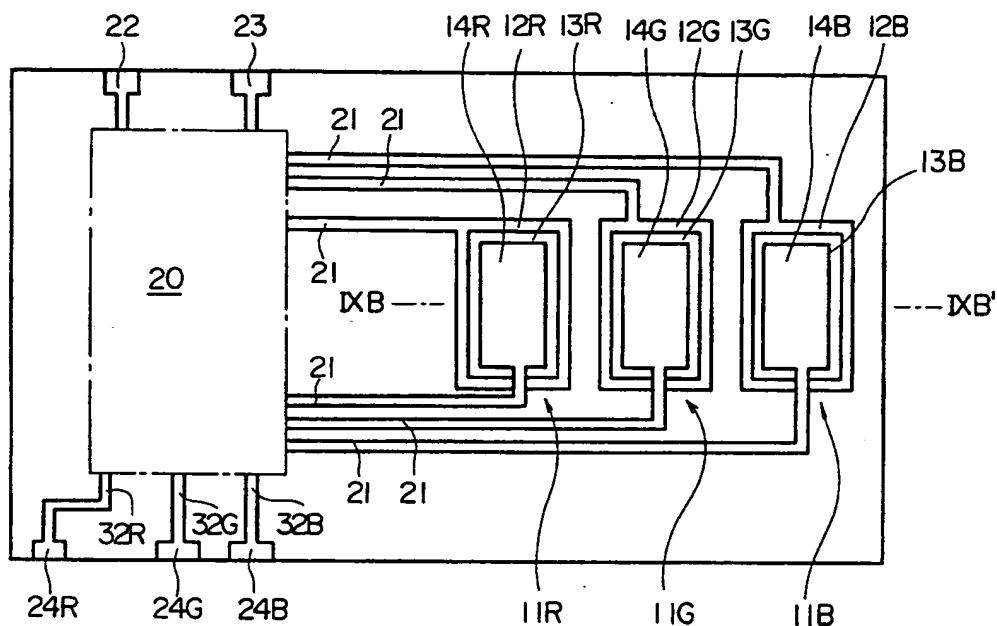
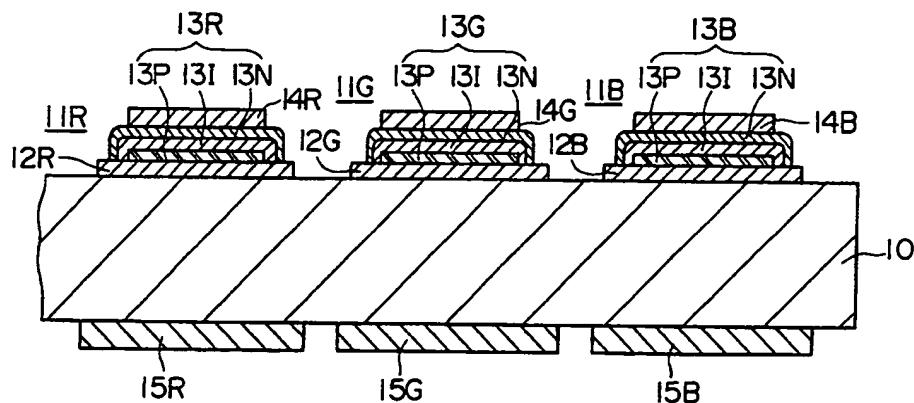


FIG. 9B



2115980

6/7

FIG. II A

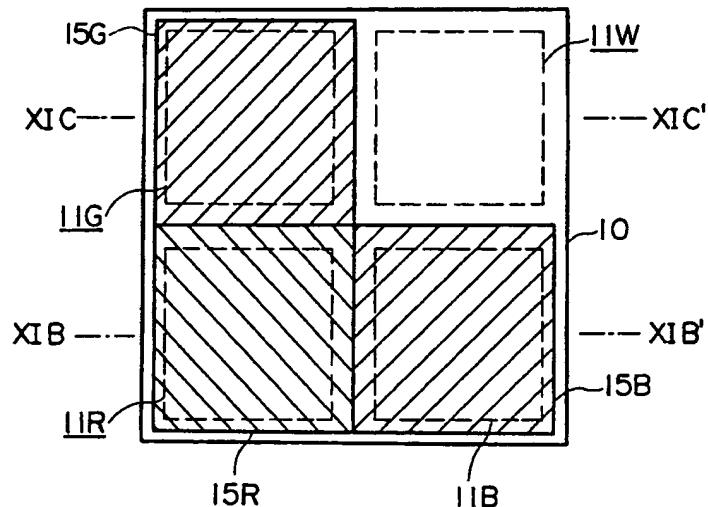


FIG. II B

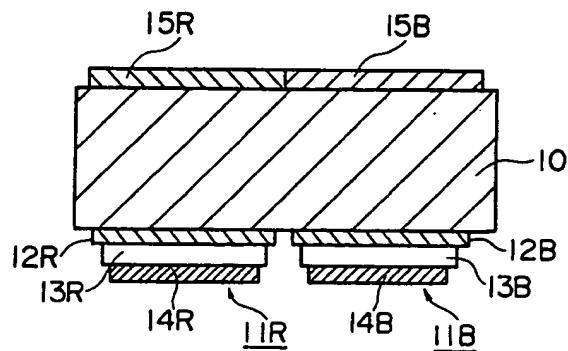
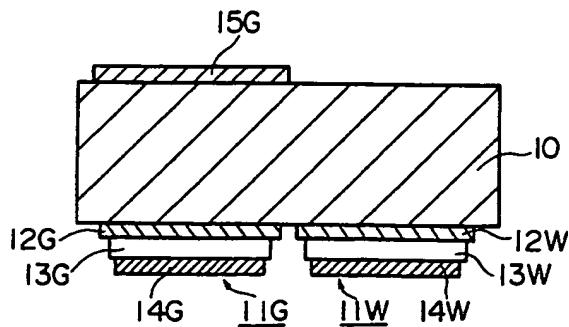


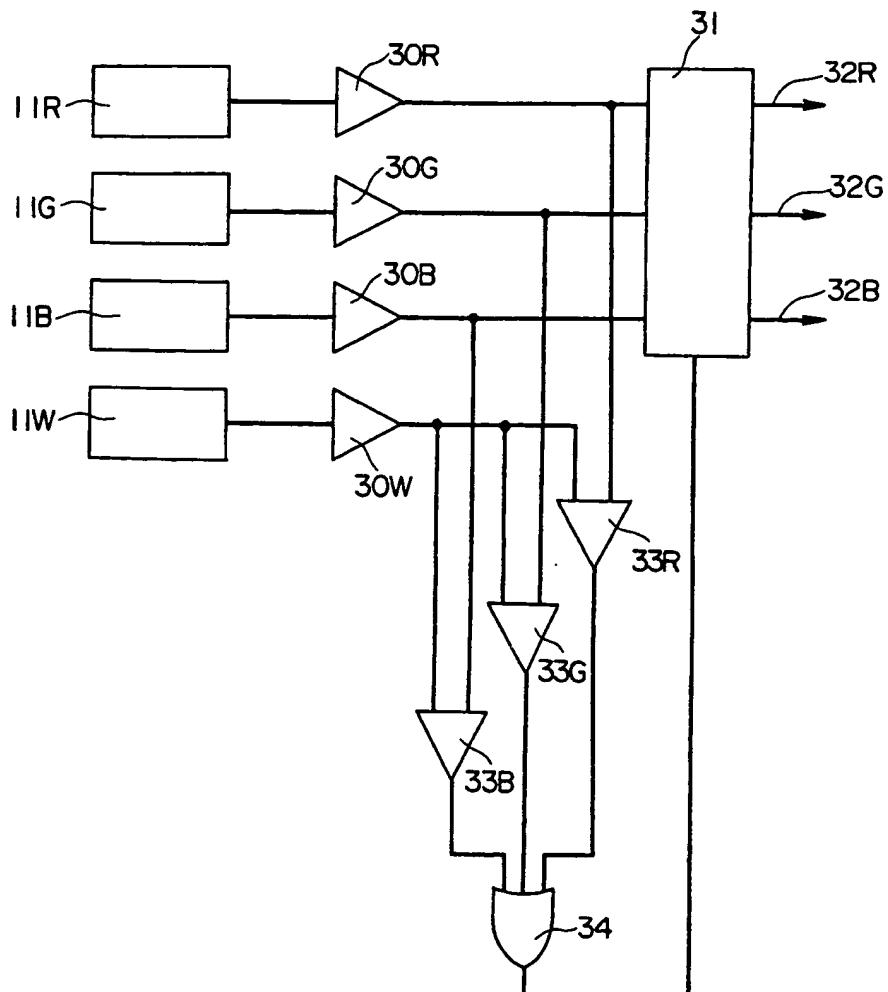
FIG. II C



2115980

7/7

FIG. 12



SPECIFICATION**Color sensor****5 Background of the invention****Field of the invention**

The present invention relates to a light sensitive apparatus which is sensitive to light in a plurality of specific wavelength zones. More particularly, the 10 present invention relates to a color sensor which is sensitive to a light in a plurality of specific wavelength zones wherein no infrared cut filter is required and a yield is improved.

15 Description of the prior art

A light sensitive apparatus which is sensitive to light included in a plurality of specific wavelength zones, using as a light active layer a single crystal silicon, that is, a so-called color sensor, has already 20 known. In principle, as shown in Figure 1, a conventional color sensor is structured such that a plurality of photodiode regions 2R, 2G and 2B which are light sensitive areas are provided on a surface of a single crystal silicon substrate 1 and optical filters having 25 different wavelength zones of transmissible light, for example, a red color filter 3R, a green color filter 3G and a blue color filter 3B are disposed on the photodiode regions, respectively, and a further infrared ray cut filter 4 are disposed on the optical 30 filters. In an operation of such sensor, in case where visible radiation is incident on the substrate 1 through each of the filter 3R, 3G and 3B, respective detection signals are outputted from a photodiode region 2R corresponding to a red color filter 3R if a 35 color included in the incident visible radiation is red, and from the photodiode region 2G corresponding to the green color filter 3G if being green, and from the photodiode region 2B corresponding to the blue color filter 3B if being blue, respectively.

40 A light sensitivity characteristic of a single crystal silicon per se presents a peak in an infrared ray region, as shown in a curve A in Figure 2. On the other hand, the red color filter 3R indicates a peak of transmittivity in a red color band, however, the band 45 characteristic extends to an infrared ray region while attenuating. Accordingly, in case where a single crystal silicon is used as a light active layer, the photodiode region 2R for detecting a red color is sensitive to not only a red color light, but also an 50 incident infrared ray through the red color filter 3R while attenuating in accordance with the above described light sensitivity characteristic, and thus color information cannot be precisely detected. The infrared ray cut filter 4 in said conventional color 55 sensor is provided for removing such incident infrared ray and hence is necessarily needed.

However, the existence of such infrared ray cut filter 4 not only makes a structure of a color sensor complicated, but also brings about a defect that a 60 fragile silicon substrate 1 is broken in the course of the step wherein the filter 4 and the respective color filters 3R, 3G and 3B are superimposed and covered on the single crystal silicon substrate 1.

65 Summary of the invention

The present invention is directed to a color sensor for detecting light in a plurality of specific wavelength zones. A color sensor in accordance with the present invention comprises a light transmissible substrate capable of transmitting light; a plurality of optical filter provided on one major surface of the light transmissible substrate, which filters have the respective different transmissible light zones; and a plurality of light sensitive elements on other

70 major surface of the light transmissible substrate opposed to the optical filter, respectively, each light sensitive elements including an amorphous semiconductor or a mixed phase semiconductor comprising an amorphous semiconductor and a microcrystallized semiconductor. In accordance with the present invention, a color sensor can be obtained wherein no infrared ray cut filter is required and yield is improved.

In a preferred embodiment of the present invention, detection of an incident light is made by utilizing a photovoltaic effect or photoconductivity effect in a light active layer.

In other preferred embodiment of the present invention, a light active layer is formed as a single 90 layer common to all of the light sensitive elements so that a simplification of manufacturing process is achieved.

In a further preferred embodiment of the present invention, a ratio of light receiving areas of a 95 plurality of light active layers is determined so that all of the light active layers have the same light sensitivity. As a result, the precision for color detection can be enhanced.

In a still further preferred embodiment of the 100 present invention, a light sensitive element is provided which is not opposed to any optical filters, which light sensitive element can be used for sensitivity compensation of a color sensor.

In a further preferred embodiment of the present 105 invention, a processing circuit is provided on one major surface of a light transmissible substrate, which processing circuit is electrically connected to light sensitive elements for processing an output from the light sensitive elements. In accordance with 110 the embodiment, an apparatus can be made in a unit manner.

Accordingly, a principal object of the present 115 invention is to provide a color sensor wherein no infrared ray cut filter is required and a yield is improved as compared with a conventional color sensor.

These objects and other objects, features, aspects and advantages of the present invention will become more apparent from the following detailed description 120 of the present invention when taken in conjunction with the accompanying drawings.

Brief description of the drawings

Figure 1 is a schematic cross sectional view 125 showing a conventional color sensor using a single crystal silicon as a light active layer;

Figure 2 is a graph showing a light sensitive characteristic of a single crystal silicon and an amorphous silicon;

Figures 3A and 3B are a schematic front view as

viewed from a light incident side of a color sensor of a preferred embodiment of the present invention and a schematic cross sectional view taken from the line IIIB - IIIB' in Figure 3A, respectively;

5 *Figure 4 shows a light transmission characteristic of a color filter used in a preferred embodiment of the present invention;*

Figure 5 is a schematic cross sectional view showing a light active layer of a PIN junction type of

10 *a color sensor of the present invention;*

Figure 6 is a schematic cross sectional view showing a light active layer of a color sensor of the present invention which is not of a junction type;

Figures 7A and 7B are a schematic front view as

15 *viewed from a light incident side of a color sensor of other preferred embodiment of the present invention and a schematic cross sectional view taken from the line VIIIB - VIIIB' therein, respectively;*

Figures 8A, 8B and 8C are a schematic front view as

20 *viewed from a light incident side of a color sensor of a further preferred embodiment of the present invention and a schematic cross sectional view taken from the line VIIIB - VIIIB' and a schematic cross sectional view taken from the line VIIIC - VIIIC'*

25 *therein, respectively;*

Figures 9A and 9B are a schematic front view as

30 *viewed from a light incident side of a color sensor of a still further preferred embodiment of the present invention and a schematic cross sectional view taken from the line IXB - IXB', respectively;*

Figure 10 shows an example of a specific structure of a processing circuit used in the Figure 9 embodiment;

Figures 11A, 11B and 11C are a schematic front

35 *view as viewed from a light incident side of a color sensor of a further preferred embodiment of the present invention, a schematic cross sectional view taken from the line XIB - XIB' and a schematic cross sectional view taken from the line XIC - XIC',*

40 *respectively;*

Figure 12 shows an example of a specific structure of a processing circuit used in the Figure 11 embodiment; and

45 *Figure 13 is a schematic front view as viewed from a light incident side showing a further embodiment of a color sensor in accordance with the present invention.*

Description of the preferred embodiments

50 Figures 3A and 3B are a front view as viewed from a light incident side in a color sensor of a preferred embodiment of the present invention and a cross sectional view taken from the line IIIB - IIIB', respectively. The color sensor comprises first,

55 second, third thin film light sensitive elements 11R, 11G and 11B provided on a light transmissible substrate 10 such as glass, plastic and the like of 0.3 mm in thickness. Color filter films inherent to each elements are provided on one major surface of the

60 substrate 10. More particularly a red color filter film 15R is provided corresponding to the first light sensitive element 11R, a green color filter film 15G is provided corresponding to the second light sensitive element 11G and a blue color filter film 15B is

65 provided corresponding to the third light sensitive

element 11B. As each of filter films, WRATTEN GELATIN FILTER made by Eastman Kodak Incorporated is preferred. For example, the lot number 25 is used as a red color filter film 15R, number 58 as a

70 green color filter 15G and number 47B as a blue color film 15B, which are fixed onto the substrate by the adhesive of transparent resin, for example. These filters have a light transmissible characteristic as shown in Figure 4. The first to the third light

75 sensitive elements 11R, 11G and 11B include stacks of layers having first electrode films 12R, 12G and 12B, light active layers 13R, 13G and 13B and second electrode films 14R, 14G and 14B deposited on other major surface of the substrate 11, respectively. The

80 respective stacks of layers are individually opposed to the corresponding filter film.

The first electrode films 12R, 12G and 12B are light transmissible electrodes comprised of a transparent electric conductive material such as tin oxide, indium tin oxide and the like and the second electrode films 14R, 14G and 14B are metallic electrodes comprised of aluminum or the like.

The light active layers 13R, 13G and 13B are

90 formed of an amorphous semiconductor or a mixed phase semiconductor of an amorphous semiconductor and a microcrystallized semiconductor which are about 1 µm in thickness. As an amorphous semiconductor, an amorphous silicon (a-Si), amorphous silicon carbide (a-SiC), amorphous silicon germanium (a-SiGe), amorphous silicon nitride (a-SiN), and amorphous silicon tin (a-SiSn) which are formed on any substrate by way of gas reaction such as glow discharge are known. The mixed phase semiconductor is of a mixture of such amorphous

95 semiconductor and a microcrystallized one thereof. In addition, hydrogen and halogen elements may be included in these substances or arsenic (As), phosphorus (P), boron (B) and aluminum (Al) may be doped. Such light active layers may be or may not be

100 of a junction type.

In operation, first it is assumed that the light active layers 13R, 13G and 13B are of a junction type such as PN junction, PIN junction, PI junction, IN junction, Schottky junction, heterophase junction, MIS junction through an insulating layer, and the like. Then, electrons and/or holes in free state are generated in the light active layers 13R, 13G and 13B by applying to the light active layers 13R, 13G and 13B light of particular wavelength regions selected by the respective color filters 15R, 15G and 15B of red, green and blue colors, which electrons and/or holes reach the respective first light transmissible electrodes 12R, 12G and 12B and second metallic electrodes 14R, 14G and 14B so that photovoltaic force is

115 generated between both electrodes 12R and 14R, 12G and 14G, and 12B and 14B, respectively. On the other hand, if the light active layers 13R, 13G and 13B do not include the above described junctions, a photoconductive phenomenon appears in which a conductivity increases due to a generation of electrons and/or holes in free state. In such a way, each of the light sensitive elements 11R, 11G and 11B is sensitive to irradiating light of a particular wavelength region and hence a signal of a level

120 corresponding to the intensity of the irradiating light

125

130

is outputted. More particularly, the ratio of wavelength components of an incident light can be obtained from the level of the output signal from each of the light sensitive elements 11R, 11G and 11B. Therefore, if and when the color filters 15R, 15G and 15B of red, green and blue colors which are three primary colors of light are used in accordance with the present embodiment, all of the color informations can be obtained.

10 The light sensitivity characteristic of an amorphous semiconductor has a band which is almost included in a visible radiation zone as shown in a curve B in Figure 2. A mixed phase semiconductor of an amorphous semiconductor and a microcrystallized semiconductor also indicates substantially the same characteristic. For this reason, in a color sensor in accordance with the present invention, even if an infrared ray is entered through a red color filter 15R, it is hardly detected and hence precise color information can be detected without using an infrared ray cut filter which is conventionally required. In addition, in a color sensor in accordance with the present invention, each of the color filters 15R, 15G and 15B is fixed to a surface of the substrate which is opposite side to the light active layers 13 and hence the light active layers 13 cannot be damaged in fixing the color filters.

Now a more specific embodiment will be described in conjunction with a manufacturing process thereof.

First, as the first light transmissible electrodes 12R, 12G and 12B, indium tin oxide (ITO) is deposited by sputtering and patterned on one major surface of the light transmissible substrate 10. Then, the light active layers 13R, 13G and 13B are formed thereon.

As described in the foregoing, the light active layers are made of an amorphous silicon semiconductor or a mixed phase semiconductor about 1 µm in thickness, the detail of which is shown in Figure 5.

40 This will be described in detail in conjunction with a manufacturing process thereof. The light transmissible substrate 10 with only the first electrodes 12R, 12G and 12B of the respective light sensitive elements 11R, 11G and 11B is disposed between reaction electrodes of a plasma reaction furnace. Then with the light transmissible substrate 10 heated at a approximately 300°C in the reaction furnace, a silane (SiH_4) gas and an impurity gas of diborane (B_2H_6) at the concentration of 1000 ppm are introduced in the reaction furnace. Then a high frequency electric power of 13.56 MHz and 100 W is applied to the above described reaction electrodes, so that a glow discharge is caused, whereby an amorphous silicon layer 13P of P-type is obtained on the light transmissible substrate 10 with the thickness of approximately 100 Å. Thereafter only B_2H_6 gas is removed and I-type amorphous silicon layer 13I is deposited at the thickness of approximately 5000 Å. Then phosphine (PH_3) serving as an impurity gas is mixed therewith at the concentration of 1000 ppm, so that N-type amorphous silicon layer 13N is formed with the thickness of approximately 300 Å. Thus, a single light active layer 13 comprised of an amorphous silicon (a-Si:H) semiconductor layer having a PIN junction with the respective P, I and N layers

stacked on the light transmissible substrate 10 is provided. Meanwhile, since the growth rate of the above described amorphous silicon layer is approximately 1 µm/nr for each of the layers, the time is controlled to obtain a desired thickness for each. Such an amorphous silicon diode manufacturing process by means of a glow discharge is well-known, as disclosed in the Japanese Patent Publication Gazette No. 37718/1978 (which counterpart 70 patents are as follows: US Patent No. 4,064,521, British Patent 1,545,897 and French Patent 2,304,180).

Then the above described light active layer 13 of the amorphous silicon semiconductor is divided by 80 means of a photoetching, a plasma pattern etching or the like, so that predetermined patterns are defined. By way of this division, the neighboring light active layers 13R, 13G and 13B are securely insulated from each other. Alternatively, the separate light active layers 13R, 13G and 13B may be selectively formed from the beginning by using a metallic mask without using the above described method.

Thereafter, the metallic electrode 14 of aluminum 90 is deposited on the above described light active layers 13R, 13G and 13B and then unnecessary portions are removed so that three light sensitive elements 11R, 11G and 11B are formed on the above described light transmissible substrate 10.

95 After formation of the light sensitive elements 11R, 11G and 11B in the above described manner, the respective color filters of red, green and blue colors are disposed on other major surface of the light transmissible substrate 10 opposed to the respective 100 light sensitive elements 11R, 11G and 11B, respectively.

In a photoconductive type which has not a conjunction, a non-doped layer (I-type layer) of 1 - 10 micron, for example, 5 micron, is formed by a glow 105 discharge in only SiH_4 gas. Electrode arrangement includes the same arrangement as that in the above described photovoltaic type wherein the light active layers 13R, 13G and 13B are interposed between a light transmissible electrodes 12R, 12G and 12B and 110 metallic electrodes 14R, 14G and 14B and also includes an arrangement wherein the light active layers 13R, 13G and 13B are directly disposed on the light transmissible substrate 10 and a pair of metallic electrodes 14 and 14' are disposed on the exposed 115 major surface with a predetermined spacing as shown in Figure 6. In accordance with the latter arrangement, not only the light transmissible electrodes 12R, 12G and 12B can be omitted, but also a slight attenuation of a transmissible light due to 120 existence of a light transmissible electrodes can be avoided.

Figure 7A is a front view as viewed from light irradiation side of a color sensor of other preferred embodiment of the present invention and Figure 7B 125 is a cross sectional view taken from line VIIIB - VIIIB' in Figure 7A. In the present embodiment, the light sensitive elements 11R, 11G and 11B comprise light transmissible electrodes 12R, 12G and 12B, a light active layer 13 comprised of an amorphous semiconductor uniformly formed over all the areas and 130

metallic electrodes 14R, 14G and 14B which are stacked in this order on the side of the light transmissible substrate 10.

Even if the light active layer 13 is formed of such a single common amorphous semiconductor layer without dividing it to each layer for each of the light sensitive elements 11R, 11G and 11B, there is almost no cross talk between each light sensitive element and hence the respective elements can be substantially insulating from each other since the amorphous semiconductor has a higher resistance value as compared with conventional single crystal semiconductor and in addition, the film thickness is an order of at most 1 micron and hence the spacings between each of the light sensitive elements 11R, 11G and 11B can be made larger than the above described film thickness. Thus, a manufacturing step can be simplified by forming each light sensitive element 11R, 11G and 11B with a single common amorphous semiconductor.

Figure 8A is a front view as viewed from light irradiating side of a color sensor which is a further preferred embodiment of the present invention, and Figures 8B and 8C are cross sectional views taken from the lines VIIIB - VIIIB' and VIIIC - VIIIC' in Figure 8A, respectively.

The present invention embodiment is intended to enhance color detecting precision in a color sensor in accordance with the present invention. More particularly, although the light sensitivity characteristic of an amorphous semiconductor has a zone or band included in a visible radiation region as described in Figure 2, it is not flat but has a peak near approximately 550 nm as shown in the figure. In addition, the transmissibility of the respective color filter films 15R, 15G and 15B are not identical as shown in Figure 4 and, particularly, the red color filter film 13R has the largest transmittivity. For this reason, the light sensitivity of the first to third light sensitive elements 11R, 11G and 11B are different from each other and thus even if the incident light with the same intensity is irradiated, different detection outputs are generated, respectively.

The most significant feature of the present embodiment is that the light receiving area in each of the light sensitive elements is different corresponding to the light sensitivity of each element and the light receiving area of the element having the largest light sensitivity is made the smallest. More particularly, the ratio of the light receiving areas of the first, second and third light sensitive elements 11R, 11G and 11B is set to about 2:3:5, so that the light sensitivity (output voltage/incident light intensity) of each light sensitive element is made substantially the same and hence a color detection is made with improved precision.

Figure 9A is a front view as viewed from a light irradiation side of a color sensor which is still further preferred embodiment of the present invention, and Figure 9B is a cross sectional view taken from the line IXB - IXB'.

In the present embodiment, a color sensor in accordance with the present invention further includes a processing circuit 20 provided on one major surface of a substrate 10, which processing circuit 20

is electrically connected to both electrode films 12R, 14R; 12G, 14G; 12B, 14B of the respective light sensitive elements and processes an output from each of the light sensitive elements.

- 70 Electrical connection of the processing circuit 20 with the above described respective electrode films is made by conduction paths 21, 22, ... extending from the respective electrode films. In addition, a power source terminal 22 and an earth terminal 23
- 75 connected to the processing circuit 20 and output terminals 24R, 24G and 24B are deposited and formed on the substrate 10.

An example of a more specific structure of the processing circuit 20 is shown in Figure 10, wherein

- 80 the outputs from the first, second and third light sensitive elements 11R, 11G and 11B enters into a maximum value detector 31 through corresponding amplifiers 30R, 30G and 30B, respectively. The maximum value detector 31 is of a well-known
- 85 structure comprising a plurality of comparators, and finds out the largest output level among the outputs from the respective amplifiers 30R, 30G and 30B and outputs the same to a line 32R if it corresponds to a red color, to a line 32G if it corresponds to a green
- 90 color, or to a line 32B if it corresponds to a blue color, respectively.

As described in the foregoing, in accordance with the present embodiment, a color sensor can be made in a unit manner since a processing circuit can be provided on a substrate of a color sensor in an integral manner.

Figure 11A is a front view as viewed from a light irradiation side of a color sensor which is a further preferred embodiment of the present invention, and Figures 11B and 11C are cross sectional views taken from the lines XIB - XIB' and XIC - XIC' in Figure 11A. The present embodiment is intended to enhance a color detecting precision of a color sensor in accordance with the present invention and thus, is characterized in that a fourth light sensitive element 11W is provided adjacent to the first, second and third light sensitive elements 11R, 11G and 11B. The fourth light sensitive element 11W is provided on the substrate 10 in the same structure and the same manner as other elements, however, it is different from other elements in that no opposed color filter is provided on the other major surface of the substrate 10.

The fourth light sensitive element 11W is used for correcting outputs of other elements, the example of use thereof being shown in Figure 12. In Figure 12, the outputs from the first, second and third light sensitive elements 11R, 11G and 11B enter into a maximum value detector 31 through their corresponding amplifiers 30R, 30G and 30B, as explained in conjunction with the Figure 9 embodiment. As described in the foregoing, a maximum value detector 31 finds out the largest output level among the outputs from the amplifiers 30R, 30G and 30B and outputs the same to a line 32R if it corresponds to a red color, to a line 32G if it corresponds to a green color, or to a line 32B if it corresponds to a blue color. In this state, for example, if light of an intermediate color between red and green, and red color being slightly more intensive than the green, is irradiated,

the maximum value detector 31 provides an output indicating that the irradiated light is red although the irradiated light is an intermediate color. In order to avoid such output state, an output from the fourth light sensitive element 11W is used. More particularly, the output passes through the amplifier 30W and then is compared in the comparators 33R, 33G and 33B with the output from other amplifiers 30R, 30G and 30B. The respective comparators 33R, 33G and 33B provide an output if the output levels from the respective first, second and third light sensitive elements 11R, 11G and 11B are larger than a predetermined rate of output level from the fourth light sensitive element 11W, the output from the comparators 33R, 33G and 33B making effective an operation of the maximum value detector 31 through an OR gate 34.

Since the fourth light sensitive element 11W does not comprise a color filter, the output level thereof is larger than those in any other light sensitive elements. The output levels from the first, second and third light sensitive elements 11R, 11G and 11B are lower than the output level from the fourth light sensitive element 11W and if incident light is of an intermediate color, the former output levels become further lower. Therefore, the ratio of the output levels from the first, second and third light sensitive elements 11R, 11G and 11B in case where incident light is not of intermediate color, and the output level from the fourth light sensitive element 11W is used as a reference and then the respective comparators 33R, 33G and 33B are designed such that the comparators 33R, 33G and 33B apply no output if the output levels from the first, second and third light sensitive elements 11R, 11G and 11B are lower than such reference. As a result, as described in the foregoing, if the light of a intermediate color between red and green is irradiated to a color sensor 10, the maximum value detector 31 does not operate and hence applies no output. Accordingly, in accordance with the present embodiment, it is possible to avoid detecting erroneously an intermediate color as other color so that a color detecting precision can be increased.

Figures 13A and 13B are still further embodiments of a color sensor in accordance with the present invention. In Figure 13A, three light sensitive regions 11 are closely disposed to be symmetrical about a center and in Figure 13B, a six light sensitive elements 11 are closely disposed to be symmetrical about a center. Optical filters 15, ... having different wavelength zones of transmissible light are provided opposed to the respective light sensitive regions 11, Since use of three primary colors of light make possible coverage of all of the visual radiation zone, a low sensitivity can be compensated by duplicately using color filters 15, ... having wavelength zone of low relative sensitivity if there are six light sensitive regions 11, In addition, color filters 15, ... of cyanic color, magenta color and yellow color which are complimentary colors of three primary colors of red, green and blue may be added.

Although not shown, an arrangement wherein a number of sensitive regions are linearly arrayed is useful, particularly, as optical reader apparatus for a

color facsimile. In this case, many units each comprising three light sensitive regions with color filters of red, green and blue are linearly arrayed.

Meanwhile, it has been known that the above 70 described amorphous semiconductors having different light sensitivity characteristics can be easily obtained by properly selecting a composition of reaction gas and composition ratio. For example, if and when reaction gas includes SiH₄ and methane (CH₄) so that an amorphous silicon carbide is formed, the light sensitivity on the shorter wavelength side increases, and if germane (GeH₄) is added to reaction gas, an amorphous silicon germanium is obtained, whereby the light sensitivity at the 75 side of longer wavelength can be increased.

Although the light transmissible electrodes 12R, 12G and 12B and metallic electrodes 14R, 14G and 14B are disposed in a separated manner with respect to the respective light sensitive regions 11R, 11G and 80 11B, any one electrode may be uniformly formed over the entire region. Particularly, if and when the light transmissible electrodes 12R, 12G and 12B are formed uniformly over the entire region, the amorphous semiconductor to be superimposed or laminated is made flat, which is much useful.

As apparent from the above described description, in a color sensor in accordance with the present invention, light active regions of light sensitive elements are formed of an amorphous semiconductor or a mixed phase semiconductor of an amorphous semiconductor and microcrystallized semiconductor which light sensitivity characteristic substantially exists in a visible radiation band and hence an infrared ray cut filter which is indispensable to

100 conventional single crystal silicon having a peak of sensitivity in an infrared ray zone can be omitted. In addition, since the light transmissible substrate serves as a protector and support in disposing optical filters defining light sensitive wavelength 105 zone, without adversely affecting fragile light active layers, the decrease of yield of apparatus can be prevented.

Although the present invention has been described and illustrated in detail, it is clearly understood that the same is by way of illustration and example only and is not to be taken by way of limitation, the spirit and scope of the present invention being limited only by the terms of the appended claims.

115 CLAIMS

1. A color sensor for detecting light in a predetermined plurality of specific wavelength zones, comprising:
- 120 a light transmissible substrate (10) capable of transmitting light,
- 125 a plurality of optical filters (15R, 15G, 15B) provided on one major surface of said light transmissible substrate (10) for transmitting the light of a particular wavelength zone to said light transmissible substrate (10), said plurality of optical filters (15R, 15G, 15B) having respective different transmissible light zones, and
- 130 a plurality of light sensitive elements (11R, 11G,

11B) provided on another major surface of said light transmissible substrate (10) opposed to said plurality of optical filters (15R, 15G, 15B), respectively and for detecting the light in said particular wavelength

5 zone transmitting through said optical filters (15R, 15G, 15B) and said light transmissible substrate (10), each of said plurality of light sensitive elements (11R, 11G, 11B) comprising a light active layer (13R, 13G, 13B) comprised of an amorphous semiconductor or a mixed phase semiconductor comprising an amorphous semiconductor and a microcrystalline semiconductor.

10 2. A color sensor in accordance with claim 1 wherein

15 said light active layer (13R, 13G, 13B) is formed in a junction type so that the detection of light by said light sensitive element (11R, 11G, 11B) is made by way of a photovoltaic force which is generated when the light is irradiated to said junction.

20 3. A color sensor in accordance with claim 1 wherein

25 said light active layer (13R, 13G, 13B) comprises a single semiconductor, so that the detection of light by said light sensitive elements (11R, 11G, 11B) is made based on an increase of conductivity of said single semiconductor which is caused when the light is irradiated to said single semiconductor.

30 4. A color sensor in accordance with any one of claims 1 to 3, wherein

35 said light active layer (13R, 13G, 13B) comprises a single layer common to all of said plurality of light sensitive elements (11R, 11G, 11B).

40 5. A color sensor in accordance with any one of claims 1 to 3, wherein

45 the ratio of light receiving areas of the light active layers (13R, 13G, 13B) respectively included in said plurality of light sensitive elements (11R, 11G, 11B) is determined such that said all of the light active layers (13R, 13G, 13B) has the same light sensitive

50 sensitivity which is a ratio of an incident light intensity to light detecting output according to a light sensitivity characteristic of the semiconductor forming said light active layer (13R, 13G, 13B).

55 6. A color sensor in accordance with any one of claims 1 to 3, which further comprises a further light sensitive element (11W) provided on other major surface of said light transmissible substrate (10) for sensitivity compensation of a color sensor, said further light sensitive element (11W) being not

60 opposed to any of said plurality of optical filters (15R, 15G, 15B) provided on one major surface of said light transmissible substrate (10), so that light transmitting said light transmissible substrate (10) not through said optical filters (15R, 15G, 15B) is detected.

65 7. A color sensor in accordance with any one of claims 1 to 3, which further comprises a processing circuit (20) provided on other major surface of said light transmissible substrate (10), said processing circuit (20) being electrically connected to said light sensitive elements (11R, 11G, 11B) and processing outputs from said light sensitive elements (11R, 11G, 11B).

8. A photodetector comprising a translucent substrate, a plurality of colour band-pass filters dis-

posed adjacent one another on one surface of said substrate, and a corresponding plurality of photosensitive elements provided on an opposed surface of said substrate and each arranged to be respective

70 to light passed by a respective one of the filters and transmitted through the substrate, each of said photosensitive elements including a photodetector comprised of an amorphous semiconductor material or of a mixed phase semiconductor material including an amorphous semiconductor material and a microcrystalline semiconductor material.

75 9. A photodetector as claimed in claim 8 wherein the material comprising said photosensitive elements is substantially as herein described.

80 10. A photosensor substantially as herein described with reference to any of Figures 3 to 13 of the accompanying drawings.

Printed for Her Majesty's Stationery Office, by Croydon Printing Company Limited, Croydon, Surrey, 1983.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.